Universiti Malaysia PAHANG
Engineering • Technology • Creativity

SUPERVISOR'S DECLARATION

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Bachelor of Civil Engineering with Honors.

____
(Supervisor's Signature)

Full Name : Dr. Putu I. Mandiartha
Position : Senior Lecturer
Date : 19 June 2017

STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

____

(Student's Signature)

Full Name : Abdul Qayyum Bin Samsuddin

ID Number : AA13122

Date : 19 June 2017

EFFECT OF CRUDE PALM OIL (CPO) AND CHANGES OF TEMPERATURE TOWARDS THE ASPHALT MIXTURE STRENGTH

ABDUL QAYYUM BIN SAMSUDDIN

Thesis submitted in fulfillment of the requirements
for the award of the
Bachelor Degree in Civil Engineering

Faculty of Civil Engineering and Earth Resources

UNIVERSITI MALAYSIA PAHANG

JUNE 2017

ACKNOWLEDGEMENTS

I would like to take this opportunity to thank my university, University Malaysia Pahang for providing me the good condition of facilities and equipment to complete this study.

I would also like to express my sincere gratitude to my supervisor, Dr. Putu I. Mandiartha, who has been very supportive in guiding and providing me informative discussion and recommendation throughout the programme. His consistent encouragement and motivation allowed me to perform and unleash my capabilities in this research field.

In addition, I would like to express my gratitude to my panel, Dr. Intan Suhana Bt. Mohd Razelan and Pn Azlina Bt Ismail to their valuable suggestions and comments on my work to allow me to improve my research outcome and meet the objectives of this study.

Apart from that, I would like to thank all the lecturers whom have taught me in every semester. They have indeed helped me to reinforce my basic knowledge and theories in this field.

Appreciation also goes to Mr Sani, and Mrs Sarah staffs of the Transportation and Highway Laboratory, UMP, for rendering their help, both time and energy. A special word of thanks is also reserved for my laboratory partners, Khaidier, Abdullah, and Eleena for their help.

A special thanks to my friend, Farid, Lukman, Syawal, Hafiz, Azfar, Nabil and others for they are always willing to share their precious knowledge and resources with me in completing this research work.

Finally, I am also grateful to my family especially to my parent, Encik Samsuddin Bin Sabri and Puan Norwati Binti Ismail for their love and encouragement all the way to the completion of my task in this programme.

ABSTRAK

Kajian ini dilakukan bertujuan untuk menentukan sama ada penambahan minyak sawit mentah (MSM) kepada campuran asfalt dengan menggunakan suhu yang tinggi dapat mengurangkan suhu tanpa menganggu kekuatan asfalt tersebut. Kekuatan asfalt dapat ditentukan melalui kestabilan, ruang udara dan juga ketumapatn yang diperolehi dalam Ujian Marshall. Sebanyak 60 campuran asfalt telah disediakan dengan menggunakan suhu dan peratus minyak sawit mentah (MSM) yang berbeza iaitu 120°C, 130°C, 140°C, 150°C, 160°C dan 170°C untuk suhu. Manakala 0.3% dan 0.5% adalah peratus minyak mentah (MSM) yang ditambah. Gred campuran bagi agregat yang digunakan dalam eksperimen ini adalah AC14. Berat maksimum untuk jumlah pencampuran agregat adalah 1200 gram manakala gred yang digunakan untuk bitumen adalah 80/100 untuk ujian penembusan. Keputusan analisis ini akan digunakan untuk menyiasat dan membandingkan kekuatan asfalt yang menggunakan suhu tinggi dan asfalt yang menggunakan suhu rendah. Teknologi ini masih lagi di peringkat kajian untuk digunakan bagi menggantikan turapan asfalt bersuhu tinggi kepada turapan asfalt bersuhu rendah.

KATA KUNCI | Campuran Asfalt Panas, Minyak Sawit Mentah, Ujian Marshall

ABSTRACT

The purpose of this study is to determine whether by adding crude palm oil (CPO) as an additive to the warm mix asphalt can reducing the temperature without compromise the strength of the asphalt mixtures. The strength of the asphalt mixtures can be determined from the stability, air void and also density which can be obtained in the Marshall Test. There are 60 asphalt mixtures that are provided with different temperature and percentage of crude palm oil (CPO) which are 120°C, 130°C, 140°C, 150°C, 160°C and 170°C and 0.3% and also 0.5% respectively. The gradation for aggregate used in this mixture is AC14. The maximum weight for total mixing of the aggregates used is 1200g while the grade for bitumen is 80/100 for penetration test. The results of this analysis can be used to investigate and compare the strength of the asphalt mixtures between the warm mix asphalt and hot mix asphalt. The outcome of this lab results is to compare whether by adding the crude palm oil (CPO) to warm mix asphalt mixtures can reducing the temperature and sustain the same strength of asphalt mixtures. The findings may be useful to change from hot mix asphalt to warm mix asphalt.

KEYWORDS | *Warm Mix Asphalt, Crude Palm Oil, Marshall Test*

TABLE OF CONTENT

DECLARATION		
TITLE PAGE		
ACKNOWLEDGEMENTS		**ii**
ABSTRAK		**iii**
ABSTRACT		**iv**
TABLE OF CONTENT		**v**
LIST OF TABLES		**viii**
LIST OF FIGURES		**ix**
CHAPTER 1 INTRODUCTION		**1**
1.1	Background Study	1
1.2	Problem Statement	3
1.3	Objective	4
1.4	Scope of Study	4
1.5	Significant of Study	4
CHAPTER 2		**6**
2.1	Overview of Global Warming	6
2.2	Green Technology in Malaysia	7
2.3	Marshall Test	8
2.4	Warm Mix Asphalt	8
2.5	Effect of Temperature to the Mixture Asphalt Content	11
2.6	Effect of Organic Additive to the Asphalt Mixture Contents	13
	2.6.1 Crude Palm Oil (CPO)	13

CHAPTER 3 METHODOLOGY **14**

3.1 Flow Chart of Methodology 14

3.2 Materials Used 14

3.2.1 Crude Palm Oil (CPO) 15

3.2.2 Coarse Aggregate 15

3.2.3 Fine Aggregate 16

3.2.4 Mineral Filler 16

3.2.5 Bitumen 17

3.3 Preparation of Samples 17

3.3.1 Aggregate Test 17

3.3.2 Bitumen Test 18

3.4 Marshall Test 18

3.5 Process of Experiment 19

CHAPTER 4 RESULTS AND DISCUSSION **20**

4.1 General 20

4.2 Marshall Mix Design 21

4.3 Mixing and Compaction Temperature 22

4.4 Marshall Test: Optimum Asphalt Content (OAC) 22

4.5 Warm Mix Asphalt with the Modified Bitumen, 0.3% (CPO) 29

4.5.1 Marshall Stability and Flow Value 30

4.5.2 Air Void, VMA and VFB 32

4.5.3 Bulk Specific Gravity 33

4.6 Warm Mix Asphalt with the Modified Bitumen, 0.5% (CPO) 35

4.6.1 Marshall Stability and Flow Value 35

4.6.2 Air Void, VMA and VFB 37

4.6.3 Bulk Specific Gravity 38

4.7 Hot Mix Asphalt with the Modified Bitumen, 0.3% (CPO) 39

4.7.1 Marshall Stability and Flow Value 40

4.7.2 Air Void, VMA and VFB 42

4.7.3 Bulk Specific Gravity 43

4.8 Hot Mix Asphalt with the Modified Bitumen, 0.5% (CPO) 45

4.8.1 Marshall Stability and Flow Value 45

4.8.2 Air Void, VMA and VFB 47

4.8.3 Bulk Specific Gravity 48

4.9 Result Findings for Modified Bitumen 50

CHAPTER 5 CONCLUSION 51

5.1 Introduction 51

5.2 Conclusion 51

5.3 Recommendations 52

REFERENCES 53

LIST OF TABLES

Table 4.1: Optimum Asphalt Content (OAC) for HMA 27

Table 4.2: Analysis parameter for HMA at (OAC) of 5% 28

Table 4.3: Analysis modified bitumen using warm mixing temperature according to the specification of JKR/SPJ/2008-S4 34

Table 4.4: Analysis modified bitumen using warm mixing temperature according to the specification of JKR/SPJ/2008-S4 39

Table 4.5: Analysis modified bitumen using hot mixing temperature according to the specification of JKR/SPJ/2008-S4 44

Table 4.6: Analysis modified bitumen using hot mixing temperature according to the specification of JKR/SPJ/2008-S4 49

LIST OF FIGURES

Figure 2.1: Typical mixing temperature range for asphalt mixtures	9
Figure 3.1: Process of Experiment	14
Figure 4.1: Binder Content vs. VFA	23
Figure 4.2: Binder Content vs. Stability	24
Figure 4.3: Binder Content vs. Stiffness	24
Figure 4.4: Binder Content vs. VMA	25
Figure 4.5: Binder Content vs. Air Voids	25
Figure 4.6: Binder Content vs. Flow	26
Figure 4.7: Modified Bitumen vs. Stability	30
Figure 4.8: Modified Bitumen vs. Flow	31
Figure 4.9: 0.3% (CPO) vs. Air Voids at warm mix temperature	32
Figure 4.10: 0.3% (CPO) vs. Density at warm mix temperature	33
Figure 4.11: Modified bitumen vs Stability	35
Figure 4.12: Modified Bitumen vs. Flow	36
Figure 4.13: 0.5% (CPO) vs. Air Voids at warm mix temperature	37
Figure 4.14: 0.5% (CPO) vs. Density at warm mix temperature	38
Figure 4.15: Modified Bitumen vs. Stability	40
Figure 4.16: Modified Bitumen vs. Flow	41
Figure 4.17: 0.3% (CPO) vs. Air Voids at hot mix temperature	42
Figure 4.18: 0.3% (CPO) vs. Density at hot mix temperature	43
Figure 4.19: Modified Bitumen vs. Stability	45
Figure 4.20: Modified Bitumen vs. Flow	46
Figure 4.21: 0.5% (CPO) vs. Air Voids at hot mix temperature	47
Figure 4.22: 0.5% (CPO) vs. Density at hot mix temperature	48

CHAPTER 1

INTRODUCTION

1.1 Background Study

Increasing of the global has caused a positive respond towards the asphalt paving industry in the construction industry. This is due to the concerns over shrinking natural resources reserves and worsening environmental conditions and caused development and deployment of warm mix asphalt (WMA) technology. Warm mix asphalt (WMA) is an innovative asphalt concrete produced at temperatures about 20˚C to 40˚C lower than the asphalt concrete that is in the production of conventional hot mix asphalt. This technology can make it possible in order to produce and place the asphalt concrete at reduced temperatures compared to conventional hot mix method. Currently, at the core of the paving industry efforts warm mix asphalt (WMA) technology lies at in order to gear practices and operations toward sustainable development.

Minimization of energy consumption, use of non-renewable resources, and reduction in the amounts of pollutants generated during the production of paving materials are required in order to practices this type of technology in the most cost effective manner. Reducing the use of virgin materials, ensure safety, comfortable and cost effective travel and also minimize waste generation are must in order for development of sustainable pavement. Asphalt concrete is a versatile and common pavement construction material produced traditionally at temperatures between 150˚C and 170˚C.

Even though emissions from asphalt plant operations are estimated to be low compared to those from other industrial operations but in order to increase sustainable development, it concerns required that the asphalt industry need to further improvement the sustainability of its practices by utilizing innovative construction materials to ensure efficiency, environmental conservation and enhanced social benefits. Warm mix asphalt (WMA) production is set in the long term. Originally this technology just being explored for its environmental benefits but warm mix asphalt (WMA) has now been discovered to have numerous construction and performance benefits.

In order to improve the pavement performances, the efficiency and also the environmental stewardship, there are several studies have been reported on the potential of warm mix asphalt. Reviews about the several of those studies in the context of pavement sustainability can be obtained from this paper. For overall, warm mix asphalt can provides substantial sustainability benefits which similar to conventional hot mix asphalt. But in some cases warm mix asphalt is better than the conventional hot mix asphalt. Sustainability benefits including lower energy use, reduced emissions, and potential for increased reclaimed asphalt pavement usage.

Warm Mix Asphalt (WMA) is well known from the other asphalt mixtures by the temperature range at 105°C to 130°C. The temperature mixing is lower by 20°C to 30°C from the conventional hot mixing temperature. The development and deployment for technology of warm mix asphalt (WMA) are produced in order to achieve the goal which is to obtain the level of strength and durability that is equivalent to or better than the hot mix asphalt (HMA). In this experiment, using an additive crude palm oil (CPO) to add into the bitumen as a modified binder. As can be known, crude palm oil (CPO) is an organic additive.

Crude palm oil (CPO) is edible oil which is extracted from the pulp of fruit of oil palms. The colour of the pulp is red which is naturally similar to the pulp due to high inactive vitamin A content. Crude palm oil (CPO) is different from the kernel oil or coconut oil. Commonly the CPO is combined or mixed with the coconut oil to make it highly saturated vegetable fat which is also used for cooking purposes. CPO is an organic additive which is liquid at 25°C used as an additive in the production of the WMA.

1.2 Problem Statement

Global concerns over the gradual depletion of non-renewable natural resources and increasing damage to the environment from greenhouse gas emissions have created greater awareness. Within the past two decades, for sustainable development practices in all spheres of human endeavour including the road construction industry. On a global scale, the amount of raw material and energy usage in the construction industry and the associated cost could be staggering.

This emphasizes the need and places responsibility on professionals within the industry to indulge in sustainable construction practices in order to ensure that the activities of today`s generation would not compromise the ability of tomorrow`s generation to meet its needs. Within the construction industry, the asphalt paving industry has responded positively towards increasing global concerns over shrinking natural resource reserves and worsening environmental conditions through the development and deployment of warm mix asphalt technology.

Warm mix asphalt (WMA) is an innovative asphalt concrete produced at temperatures about 20°C to 40°C lower than those employed in the production of conventional hot mix asphalt and makes it possible to produce and place the asphalt concrete at reduced temperatures compared to conventional hot mix methods. Currently, warm mix asphalt (WMA) technologies lies at the core of the paving industry`s efforts to gear practices and operations toward sustainable development.

The motivation for warm mix asphalt (WMA) development was derived from Kyoto Protocol which emphasized a worldwide concerted effort to reduce greenhouse gas emissions into the atmosphere. More recently, though additional impetus has come from the United Nations Climate Summit held on September 23, 2014 in New York at which world leaders and several organizations announced strong commitments to cut greenhouse gas emission.

REFERENCES

Abdullah, M.E. et al., 2014. Jurnal Teknologi Warm Mix Asphalt Technology : A Review. , 3, pp.39–52.

Button, J.W. et al., 2004. Performance Tests for. , (September).

Carmen, M. et al., 2012. Warm Mix Asphalt : An overview. *Journal of Cleaner Production*, 24(March), pp.76–84. Available at: http://dx.doi.org/10.1016/j.jclepro.2011.11.053.

Chamber, D., 2003. Introduction To , and Impacts Of , the Kyoto Protocol On Saskatchewan , Canada , and the World. , (July).

Croteau, J. & Eng, P., 2008. Warm Mix Asphalt Paving Technologies : a Road Builder ' s Perspective. , pp.1–12.

Ebrahim, A. & Behiry, A.E., 2013. Laboratory evaluation of resistance to moisture damage in asphalt mixtures. *Ain Shams Engineering Journal*, 4(3), pp.351–363. Available at: http://dx.doi.org/10.1016/j.asej.2012.10.009.

Fakhri, M. & Ahmadi, A., 2017. Recycling of RAP and steel slag aggregates into the warm mix asphalt : A performance evaluation. *Construction and Building Materials*, 147(April), pp.630–638. Available at: http://dx.doi.org/10.1016/j.conbuildmat.2017.04.117.

Farooqi, M.U. et al., 2015. Analysis of Moisture Susceptibility of Different Loose Coated Asphalt Mixtures. , 20(I), pp.1–8.

Garber, N.J. et al., 2002. Traffic and Highway.

Goh, S.W., 2012. Development and improvement of warm-mix asphalt technology.

Jamaluddin, F. & Ibrahim, A., 2016. EXAMINING THE RELATIONSHIP BETWEEN ENVIRONMENTAL AWARENESS AND GOVERNMENT TOWARDS GREEN TECHNOLOGY IMPLEMENTATION AMONG. , 1(5), pp.196–204.

Jamshidi, A., Othman, M. & You, Z., 2013. Performance of Warm Mix Asphalt containing Sasobit Ò : State-of-the-art. *Construction and Building Materials*, 38, pp.530–553. Available at: http://dx.doi.org/10.1016/j.conbuildmat.2012.08.015.

Joshi, D.B., CIVIL ENGINEERING OPTIMUM BITUMEN CONTENT BY MARSHALL. , 2(2), pp.104–108.

Kilas, M. & Vaitkus, A., 2008. WARM MIX ASPHALTS RESEARCH , ANALYSIS AND EVALUATION.

Kristjansdottir, O., 2006. Warm Mix Asphalt for Cold Weather Paving.

Prof, A., 2007. METHODOLOGY FOR DETERMINING MOST SUITABLE COMPACTION TEMPERATURES FOR HOT MIX ASPHALT Hassan Youness Ahmed. , 33(4), pp.1235–1253.

Prowell, B.D. et al., FIELD PERFORMANCE OF WARM MIX ASPHALT AT THE NCAT TEST TRACK. , (843).

Review, A., 2017. applied sciences Adhesion Promoters in Bituminous Road Materials : A Review.

Sangiorgi, C. & Sangiorgi, C., 2016. Warm Mix Asphalt (WMA) technologies : Benefits and drawbacks — a literature review. , (January).

Shafabakhsh, G.H. & Sajed, Y., 2014. Case Studies in Construction Materials Investigation of dynamic behavior of hot mix asphalt containing waste materials ; case study : Glass cullet. *Case Studies in Construction Materials*, 1, pp.96–103. Available at: http://dx.doi.org/10.1016/j.cscm.2014.05.002.

Wang, T. et al., Reducing greenhouse gas emissions through strategic management of highway pavement roughness.

Woodward, A., Climate change and human health Editors.